

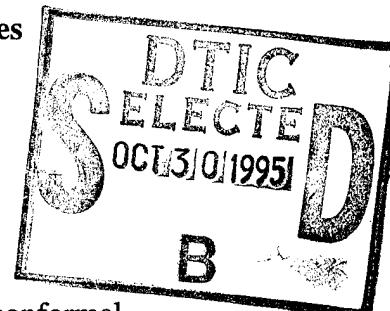
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**Technical Report** Item # 0001AB  
Date 15<sup>th</sup> April 1995

Contract # : N00014-94-C-0169  
Topic # : BMDO 94-014

**Title :** **Polymer Light Emitting Diodes on Silicon Substrates for Optical Chip interconnects**

Principal Investigator : Ian D. Parker



Work for the last month has focussed on two main areas : (i) spinning conformal, thin films of the electroluminescent polymer onto the patterned Si circuit, and (ii) fabricating test LEDs onto substrates with electrodes made from oxidised aluminium - to mimic the electrodes fabricated on the Si circuit.

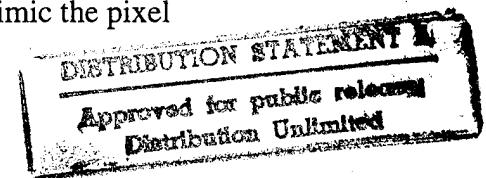
(i) *Conformal coatings*

The design of the silicon integrated circuit (onto which the polymer LEDs will be fabricated) gives rise to a non-planar surface (see figure 1). The magnitude of the surface roughness was measured using a DEKTAK profilometer showing maximum peak-to-valley differences of ~ 14,000Å (see figure 2). This may cause problems for the LED fabrication since the polymer film is ideally only ~ 1000Å and this film must be uniform to better than 10%.

Spin-coating tests were performed to determine how uniformly the polymer coats this rough surface. Figure 3 shows that the coating is reasonably conformal with the valleys being covered slightly more deeply than the peaks, resulting in a coated peak-to-valley difference of ~ 10,000Å. The 40 micron repeat structure of the pixels can easily be seen.

Electron microscope examination of the spin-coated layers is in progress.

(ii) Devices were fabricated on Al / Al oxide substrates in order to mimic the pixel surface on the Si substrates.



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500Å of Al was evaporated onto glass substrates. These were then exposed to air at 90°C for 24 hours in order to grow an oxide layer. The electroluminescent polymer (MEH-PPV - described in earlier reports) was subsequently spin-coated to a thickness of 2200Å onto the Al / Al oxide, the films were dried and finally 200Å thick semitransparent electrodes were evaporated onto the polymer. Since it was not clear whether Al / Al oxide electrodes were more efficient at injecting holes or electrons into the LED both configurations were tried. Using a calcium top electrode (which injects electrons) the ability of Al / Al oxide to inject holes was tested. Using a gold top electrode (which injects holes) the ability of Al / Al oxide to inject electrons was tested.

The best results were obtained with calcium electrodes indicating that Al / Al-oxide injects holes better than electrons. These devices emitted light for biases above 25 V with an external quantum efficiency  $\sim 10^{-3}$  %. Light-emission was through the semitransparent Ca electrode. Figure 4 shows typical I-V and light-emission characteristics.

These performance figures are not especially impressive but should be sufficient to demonstrate the principle of light emission from these devices. The oxide layer may be much thicker for these substrates than on the final device due to the oven bake. Also the polymer thickness is considerably thicker than the ideal value (which would be  $\sim 1000\text{\AA}$ ). Reducing the oxide thickness and the polymer thickness will lower the operating voltage considerably and will probably lead to an increase in the device efficiency. This work is currently underway.

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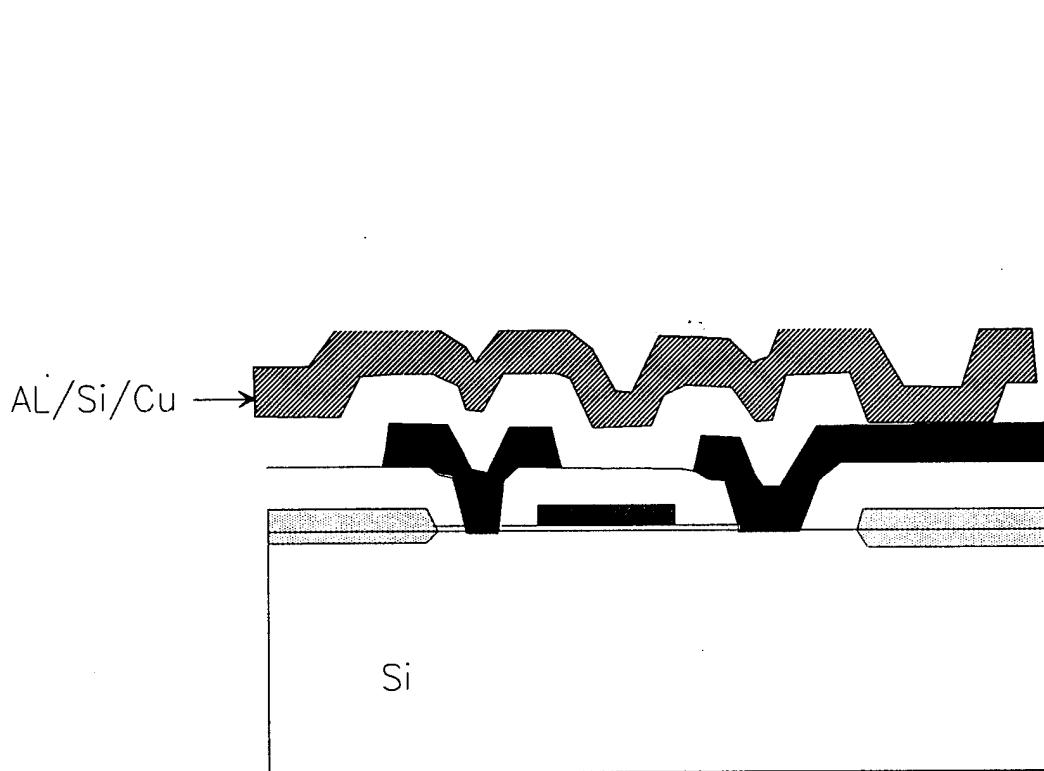


Figure 1 Schematic of the cross-sectional structure of the Si substrate with circuitry, indicating the rough surface onto which the LEDs will have to be fabricated.

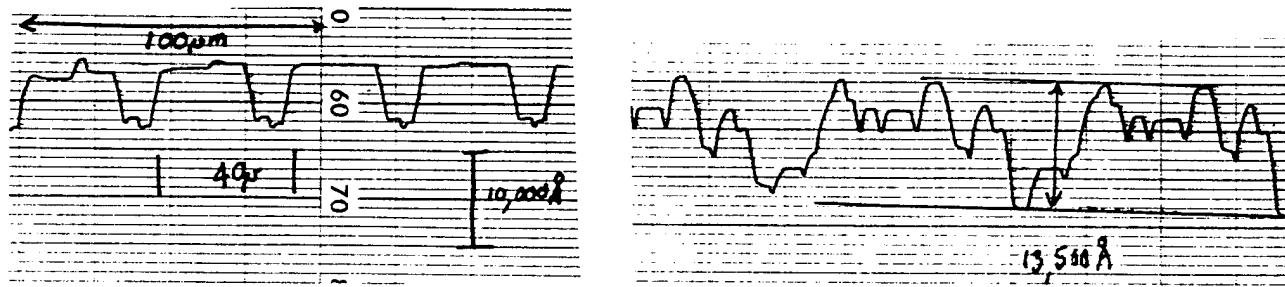


Figure 2 DEKTAK profile of the uncoated circuit showing that the surface roughness gives peak-to valley differences of  $\sim 14,000\text{\AA}$ .

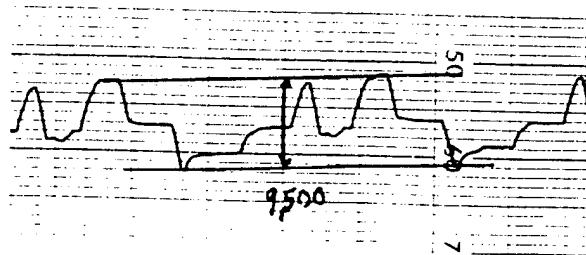
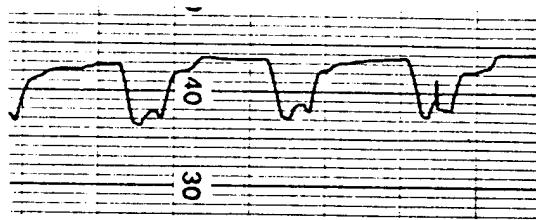


Figure 3 DEKTAK profile of the coated circuit showing a reasonably conformal coating with peak-to valley differences of  $\sim 10,000\text{\AA}$ .

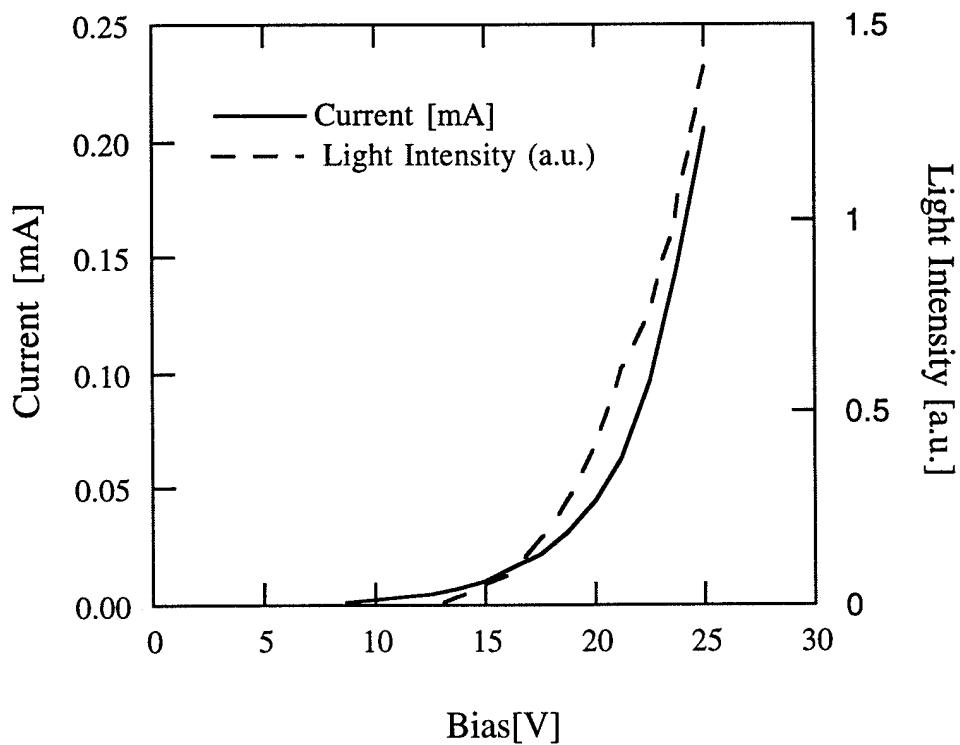


Figure 4. The I-V and light emission characteristics for the Al / Al oxide / MEH-PPV / Ca device described in the text.



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TECH REPORT  
N00014-94-C-0169  
TITLE: POLYMER LIGHT EMITTING  
DIODES ON SILICON SUBSTRATES FOR  
OPTICAL CHIP INTERCONNECTS

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